Materials, Issues, and Advancements

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Introduction by Charles M. Zeh: Our last speaker before we bring the panel together is Wate Bakker. Wate is with the Electric Power Institute. Wate will be talking about materials aspects with the advanced technologies.

Introduction

For those who expected John Stringer to be speaking, he had to go to an EPRI meeting in San Diego tomorrow morning and so he had to leave a little bit early. Instead of listening to an English accent, you have to listen to a Dutch accent now for the next 5 minutes. Many of the speakers before me, and especially Dave Stephens, have already said a lot of the same things I was going to say. So I will limit my talk to my primary fields concerns. By primary concern, I do not mean how good the machine is, but whether it will last for 20 years. How can we manage it so it stays on line? The major material issues are hot gas cleanup materials: the single crystals, and more specifically, the various coatings you have to put on top of the crystals in order for the ATS to run smoothly.

Single Crystal Alloys

So let's first say a little bit about single crystal alloys. We are concerned that the trend in the Aerospace industry has been towards lower and lower chromium contents. This makes the blade itself vulnerable to hot corrosion and oxidation. So we have to rely more and more on the coatings in order to keep the machines operating. It's somewhat frightening that the only thing standing between you and disaster is couple of mills of metallic or ceramic material. So, to avoid this potential disaster, we try to avoid anything that can contaminate that end to the gas turbine. If there were such an entity as absolutely clean natural gas or absolutely clean air, there probably would be no problem. However in the real world, the filters will not always work and natural gas will not always have the highest purity. So you must face the possibility of operation that is slightly off specifications. Such operation can quickly lead to deterioration and forced outages. Thus, we have to be extremely careful that the filter system works really well and that we use the most recent failure mechanisms. We do get a slight but acceptable accumulation of sulfate in the compressor, which occasionally goes through the turbine and may cause some damage.

Thermal Barrier Coatings

Thermal barrier coatings are probably the most sensitive component in the whole gas turbine program. The purpose of a barrier coating is to prolong blade and vane life. However, in the next generation, these coatings will be prime reliant. Thus, they basically will have to last a minimum of 25,000 hours. However, thermal barrier coatings have not been proven in the field to last for 25,000 hours satisfactorily, and especially not on land where the chance of contamination is higher than in the air. Also, the idea that these ATS machines will run at base load is not entirely correct. Service records show that the turbines will cycle quite a bit. So the thermal barrier coatings must not only last for 25,000 hours, they will have to withstand numerous cycles, both benign cycles as well as turbine trips where you lose the loads all of a sudden, and your turbine decreases in temperature from 2,600 °F to 600 °F or so in a matter of seconds. So cycling resistance is important.

However, in the long run, the failure mechanism for thermal barrier coatings is determined by sintering of the thermal barrier coating and the oxidation of the bond coat below it. There have been some reports that indicated sintering and contamination on the surfaces of the thermal barrier coatings caused relatively early failure. These mechanisms are not entirely understood and need more study. Finally, other speakers have already noted that repair and refurbishment are major issues. Can you take them off? Can you recoat them? Hopefully, you will only need to take them off and recoat once every 25,000 hours.

Bond Coats

A little bit about bond coats. First of all, we have repair problems with bond coats. Bond coats quite often will degrade during service. While thermal barrier coatings apparently are relatively easy to remove, bond coats are quite often more difficult to remove. So this is an area we need to research further. The other point is whether or not we can control variation in the bond coat. I was interested to hear a previous speaker note that it was possible to measure the growth of alumina scale on the bond coat. This is very encouraging, because it could be a means of monitoring the degradation in the bond coat. As you probably know, bond coats gradually lose their aluminum content to the point that the alumina scale does not form anymore. Then you get rapid oxidation and failure.

That’s basically all I have to say. We are looking forward to working with DOE and the utility members to help manage the introduction of this exciting new technology. Thank you very much.